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Proceedings of the Regional Peer Review of the Musquash Estuary Marine Protected Area (MPA) Monitoring Data: Part 2 - Assessment

June 25-27, 2013
St. Andrews, New Brunswick

September 19, 2013
Via Teleconference

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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TABLE OF CONTENTS

SUMMARY iv
INTRODUCTION 1
ECOLOGICAL DATA ASSESSMENT (JUNE 25-27, 2013) 1
Introduction 1
Presentation Highlights 1
Discussion 1
Review of Monitoring Data 2
Benthic Biodiversity 2
Physical Environment 3
Phytoplankton 4
Birds 5
Juvenile Fish 7
Sediment Dynamics 7
Human Ecosystem Pressures 8
Habitat Classification 9
Review of Recommended Changes to the Indicators, Strategies, and Protocols 10
Discussion 10
Review of Data Management Practices 11
Discussion 11
ECOLOGICAL DATA ASSESSMENT (SEPTEMBER 19, 2013) 12
REFERENCES CITED 12
APPENDIX 1 13
ATTENDEES 13
APPENDIX 2 15
TERMS OF REFERENCE 15
APPENDIX 3 18
DRAFT AGENDA 18

SUMMARY

Part II of a Maritimes Regional Science Advisory Process on the review of the Musquash Estuary Marine Protected Area (MPA) monitoring data was held from June 25-27, 2013, at the Huntsman Marine Science Centre, in St. Andrews, New Brunswick, and reconvened via teleconference on September 19, 2013. Participants reviewed a summary of current monitoring and research activities completed in the Musquash Estuary MPA to assess whether collected data provides an adequate baseline for on-going monitoring of the MPA and whether the indicators are likely to be effective in assessing ecosystem change. The meeting was attended by DFO staff from Science, Resource Management, and Oceans and Costal Management, as well as representatives from Environment Canada, Huntsman Marine Science Centre, Conservation Council of New Brunswick, and Bird Studies Canada.

This Proceedings Report summarizes the relevant discussions and presents the key conclusions reached at the meetings. In addition, a Science Advisory Report (SAR) and a Research Document resulting from the meeting will be published on the DFO Canadian Science Advisory Secretariat Website.

Compte rendu de la réunion d'examen par les pairs des données de surveillance de la zone de protection marine (ZPM) de l'estuaire Musquash : Partie 2 – Évaluation; 25-27 juin et 19 septembre 2013

SOMMAIRE

La partie II du processus d'avis scientifique régional des Maritimes sur l'examen des données de surveillance de la zone de protection marine (ZPM) de l'estuaire Musquash s'est déroulée du 25 au 27 juin 2013, au Centre des sciences de la mer Huntsman à St. Andrews au Nouveau-Brunswick, et a été reprise par téléconférence le 19 septembre 2013. Les participants ont examiné un sommaire des activités de surveillance et de recherche actuelles réalisées dans la ZPM de l'estuaire Musquash afin d'évaluer si les données recueillies fournissent une référence adéquate pour la surveillance continue de la ZPM et si les indicateurs seront potentiellement efficaces dans l'évaluation du changement écosystémique. Ont participé à la réunion le personnel des Sciences, de la Gestion des ressources et de la Gestion côtière et des océans du MPO, et des représentants d'Environnement Canada, du Centre des sciences de la mer Huntsman, du Conseil de la conservation du Nouveau-Brunswick et d'Études d'Oiseaux Canada.

Le présent compte rendu résume les discussions pertinentes et présente les conclusions importantes tirées de la réunion. En outre, un avis scientifique (AS) et un document de recherche découlant de la réunion seront publiés sur le site Web du Secrétariat canadien de consultation scientifique du ministère des Pêches et des Océans.

INTRODUCTION

The Chair of the meeting, E. Kennedy, welcomed participants. Meeting participants introduced themselves (Appendix 1) and the Chair thanked them for attending the DFO Science Advisory Process to review data from current monitoring and research activities completed in the Musquash Estuary Marine Protected Area (MPA).

The Chair noted that this was a science peer-review meeting and advisory meeting, meaning the primary goals of the meeting were 1) to provide an objective review of the working paper to ensure information was complete, and 2) to review the science advisory report based on this information.

The Chair provided a brief overview of the Canadian Science Advisory Secretariat (CSAS) science advisory process and invited participants to review the meeting Terms of Reference (Appendix 2) and Agenda (Appendix 3). No revisions or corrections were made to the Terms of Reference or Agenda.

To guide discussion, a working paper had been prepared. A Science Advisory Report (SAR) was also to be produced as a result of this meeting. This Proceedings report is the record of the discussion of the meeting.

Due to time constraints, the Science Advisory Report (SAR) was not finalized during the meeting on June 25-27, 2013. The meeting was reconvened on September 19, 2013, via teleconference at the Bedford Institute of Oceanography, September 19, 2013, to finalize the SAR.

ECOLOGICAL DATA ASSESSMENT (JUNE 25-27, 2013)

Introduction

Presentation: Summary of Musquash Estuary MPA Monitoring Framework and 2010 Science Advisory Report (SAR)
Presenter: E. Kennedy
Rapporteur: L. Bennett

Presentation Highlights

An overview was presented of the Science Branch of Fisheries and Oceans Canada's (DFO) commitments in support of the Health of the Oceans Initiative as they relate to the development of the scientifically-defensible indicators, strategies, and protocols for monitoring the conservation objectives of the Musquash MPA. Conservation objectives of the MPA were presented followed by a summary of the Science Advisory Report for the Musquash MPA Monitoring Framework. Fifteen ecological indicators were proposed within the SAR to monitor the MPA, along with strategies and protocols. The SAR noted a lack of baseline data existed for many of these indicators. As baseline information improves and proposed strategies and protocols are implemented and evaluated, a number of indicators may be refined or removed from the MPA monitoring plan. In addition, improved baseline data may reduce the sources of uncertainty associated with understanding the functioning of the MPA ecosystems and the likelihood of serious impact that human activities may have on the ecosystem. It was also noted that monitoring threats to the structure and function of the ecosystem is vital to understanding the potential impacts of threats, causality of subsequent ecological change, and options for managing and mitigating the pressures and impacts.

Discussion

There were no questions or discussion following this presentation.

Review of Monitoring Data

Benthic Biodiversity
Presenter: A. Cooper
Rapporteur: L. Bennett

Presentation Highlights

Sampling activities over the past three years have focused on establishing a baseline for benthic fauna, specifically species diversity and abundance, in three different habitat types or strata: the intertidal, subtidal and narrow channel of the MPA. Sampling has focussed on benthic macrofauna given their numerous ecosystem functions which include: habitat enhancement and stabilization, food source for larger organisms, nutrient capture through water filtration, and consumption of dead and decaying material. It was noted that the benthic zone is a good candidate for monitoring changes in the MPA as the area is less subject to extreme conditions when compared to the water column or exposed shoreline; thus, observed changes indicate a response to sustained events.

The sampling design, which included the collection of 3 grab samples at 10 stations within each of the 3 strata for 3 sampling periods (spring, summer, fall), has resulted in the collection of a total of 147 benthic sampling grabs over 3 years. It was reported that only the summer sampling period was completed for all 3 years.

An analysis of the data suggests that current sampling efforts are sufficient to establish baselines for species richness and diversity within the different strata, as well as dominant taxa with the understanding that monitoring change against this baseline will require an equivalent sampling effort with respect to temporal and spatial scales. Furthermore, a correlation analysis between species diversity and environmental variables would aide in understanding ecosystem function and provide more informative baseline data. For example, grain size analysis could be further explored to look at sediment quality and the associated impact on species abundance and diversity.

It was noted that the effort and costs to maintain the current monitoring activities are not trivial. For on-going sampling and processing, consistent operational support is required and approximately $10,000 is needed annually for sample sorting and processing. This does not include the costs required to collect the samples or analyze and interpret the data.

Discussion

There was a discussion concerning the level of sampling effort that is required to obtain a precise estimate of species richness and diversity and whether intensive sampling over a shorter timeframe would yield similar results. To date, 146 sampling grabs have been collected over 5 sampling periods in a 3 year period. It is unclear if more intensive sampling over a 1 year period would provide the same results as the data is not available. The summer sampling season is the only season completed for all 3 years and additional analysis completed on a subset of the data would result in less confidence and lower precision.

There was a discussion as to whether future sampling efforts should focus on the summer season due to the cost and logistics associated with sampling in the winter and the baseline data which exists for the summer season. It was noted however, that seasonality differences will not be apparent if sampling is restricted to one season; thus, data should continue to be collected in other seasons when possible.

The magnitude of change from a baseline value that would result in management action for this indicator as well as the other indicators was also discussed. Once this deviation from the baseline is identified, discussion is needed to determine the acceptable level of sampling frequency required to defensibly calculate such deviation.

Physical Environment

Presenter: F. Page
Rapporteur: L. Bennett

Presentation Highlights

There are two inflows into the Musquash MPA from the drainage system; the east branch and west branch of the Musquash River, both of which have active dams which results in human-controlled (versus natural) freshwater input to the MPA. Freshwater monitoring activities over the past three years have focussed on examining the temporal variations of river discharge and quantifying freshwater inputs. A nearby river, the Lepreau River, is not dammed and it is gauged (i.e., monitored by freshwater gauges) by Environment Canada. Future freshwater monitoring should include continued monitoring/recording of river water levels and discharge rates to determine freshwater flux from the river inputs to the Musquash Estuary. There also needs to be further research into determining how influential freshwater input is to the MPA ecosystems. If the influence is significant, then changes to freshwater input via the dams could pose a significant challenge to addressing the Conservation Objectives.

Physical and biological parameters, including temperature, salinity, turbidity, oxygen and chlorophyll, have also been monitored in the Musquash River. Conductivity, temperature, and depth (CTD) transects were completed by DFO and by the Conservation Council of New Brunswick (CCNB) during their annual Musquash Paddle. Transects indicate both temperature and salinity have strong gradients with temperature decreasing and salinity increasing from the head to the mouth of the estuary. It was also shown that the saline water mass moves back and forth in the estuary due to tidal flows and freshwater inputs, however, the maximum penetration of the saline water into the estuary is not known, which would influence the physical parameters of the habitat and the associated biological communities. In addition to the natural fluctuations of the water masses, time series data also shows episodic events that can significantly alter the physical characteristics of the water column and hence affect resident communities. It may be important to determine a proxy for such episodic events.

Effort has also been directed to modelling water circulation of the Bay of Fundy immediately outside the Estuary. A 3D finite model used to model water circulation indicates a net flow of water out of the west, a net flow of water into the east side of the estuary, and a net bottom flow into the estuary at Five Fathom Hole. Results of earlier modelling completed by John Hughes Clark of the Ocean Mapping Group at the University of New Brunswick were also presented.

Although it was noted that the indicators monitored are likely to be effective in understanding the physical component of the ecosystem, it was suggested that data collected pertaining to freshwater input, temperature, salinity, oxygen, and chlorophyll does not provide an adequate baseline for ongoing monitoring. Due to the manipulation of water flow from the Musquash River, freshwater input into the Musquash Estuary will need to be monitored continuously. To capture tidal, seasonal, inter-annual, and event variability trends in temperature, oxygen, and chlorophyll additional time series data is required. Furthermore, research efforts on determining nutrient levels and nutrient fluxes in the system would be beneficial for understanding ecosystem processes.

It was noted that ongoing science activities in the area do require resources including funding, personnel, and assets (e.g., boats, sampling equipment, etc.) to complete data collection, processing, analyses, interpretation, and advice to managers.

Discussion

It was questioned whether obtaining a baseline value of freshwater input was achievable since water flow is manipulated through the opening and closing of gates of the Musquash dam based on the water supply for the city of Saint John as well as recreational activity and flood protection.

It was noted that water levels in the east Musquash dam are recorded every hour by the Department of Natural Resources. Freshwater flow could therefore be calculated from the gate position, water level, and spillway dimensions, and this has been modelled during dam safety review analysis.

Phytoplankton

Presenter: J. Martin
Rapporteur: L. Bennett

Presentation Highlights

Sampling design and trends of a long term phytoplankton monitoring program in the Bay of Fundy, initiated in southwest New Brunswick in 1988, were reviewed. Sampling at the Wolves islands, Deadmans Harbour, Lime Kiln, Passamaquoddy Bay, and Brandy Cove occurs at weekly intervals between April and late October and monthly during the remaining months, November to March. Data from phytoplankton analyses indicate patchy species distributions, high interannual variability and strong seasonal patterns in phytoplankton species and abundance, with the dominant species varying between years. The highest number of observations occurs from April to November. Generally, peak abundance for dinoflagellates occurs from June to August for dinoflagellates and spring and fall for diatoms, with the fall diatom bloom having a larger biomass than the one in spring. The total number of phytoplankton species has been increasing since 1988.

Since 1995, 36 new species (comprised of 19 diatom, 11 dinoflagellates, and 5 "other" species that include silicoflagellates, ciliates and small zooplankton), have been detected in the Bay of Fundy. These new species have been detected every year since they were initially detected and during some years have been abundant. The year 1995 was used as the baseline for the classification of species as new to the region. Ballast water discharge has been identified as one method of introduction. Current data do not show that any species have been lost from the region. A longer time series is required to determine if any species disappear in the future.

It was recognized that very little phytoplankton sampling has been completed in the Musquash Estuary. In comparison to other sampling sites in Passamaquoddy Bay and the Bay of Fundy, results from the samples collected in Musquash indicate the presence of the same species; however, phytoplankton concentrations were very low.

Discussion

There was a discussion as to whether phytoplankton is a suitable indicator and whether results from the Bay of Fundy monitoring program could be used as a proxy for the MPA. It was suggested the existing monitoring program could act as a baseline and occasional sampling within the MPA could serve as a reference. However, participants noted several issues which could prohibit the use of phytoplankton as an indicator. There is a lack of regular sampling and baseline data from within the MPA. It was suggested that the influence of freshwater input on phytoplankton populations might prevent any data from being used as a baseline for comparison to samples collected from Passamaquoddy Bay, Lime Kiln Bay and other sites in the Bay of Fundy; although some of the inshore sites presently monitored could provide a reference and do provide evidence of brackish water species. In addition, the significant amount of sampling required to capture trends and establish a baseline within the MPA is not considered feasible.

It was questioned whether remote sensing products determining ocean colour that measure chlorophyll concentrations could serve as a proxy for phytoplankton abundance. A project that is currently underway is trying to detect *Alexandruim fundyense* (i.e., dinoflagellate) in the Bay of Fundy through the use of remote sensing tolls and specific algorithms. Past comparisons with remote sensing images have shown that it can be difficult to determine phytoplankton

abundance as the varying levels of chlorophyll produced by different species may not appear on the images, species are patchy in distribution, and the image resolution is not fine enough to focus on an area as small as Musquash; however, it is sufficiently advanced to identify individual species. It is unlikely, at the current time, that remote sensing products would be effective in the MPA due to the high turbidity of the water. Additionally, data cannot be captured during adverse weather conditions such as cloud cover and fog.

Birds

Presenters: K. Allard and M. Campbell
Rapporteur: L. Bennett (3 presentations)

Presentation 1 Highlights

An overview of collected marine bird data from **Environment Canada's Canadian Wildlife Service** that may be appropriate for future monitoring within the MPA was presented.

The Coastal Waterfowl Survey database is an aerial survey repository which contains information on waterfowl distribution and abundance collected through various monitoring programs, including the Waterfowl Winter Survey and Eider Breeding Season Survey. Incidental records of non-waterfowl species (e.g., Purple Sandpiper) also can be found within this database. The Coastal Waterfowl Survey database was initiated in 1960. The geographical scope of this database is of Atlantic Canada, but data are organized within polygons which encompass an area greater than the MPA.

The Eider Winter Survey dataset is an aerial survey which targets the Common Eider during the non-breeding period. The survey, starting in 2003, occurs every 3 years, though not all areas are surveyed with this frequency. Data are gathered as georeferenced points associated with eider flocks (from individuals to large flocks). Though some points associated with small flocks fall within the MPA, large congregations of wintering ducks typically occur outside of the MPA.

The Atlantic Canada Shorebird Survey is a multi-species (shorebirds) ground survey initiated in 1974. Completion of this survey is largely reliant on the availability and participation of volunteers. Data are gathered as georeferenced points. There are currently no survey sites located within the MPA, therefore, consequently spatial patterns derived from the point data reflect lack of survey effort within the MPA as opposed to lack of use of the site by shorebirds.

The Atlantic Region Colony Database, which contains information on multiple species of colonial waterbirds, was initiated in 1960; however, survey frequency is variable and is very limited within the MPA. Data are gathered as georeferenced points associated with colonies. Only Great Black-backed Gull and Herring Gull are listed as breeding on Gooseberry and Musquash islands, respectively, though evidence exists suggesting other species establish colonies on these islands.

Discussion

There was a discussion concerning the use of potential datasets to provide baseline data for future monitoring. Of the datasets described above, the Atlantic Canada Shorebird Survey was recognized as having the most potential given existing locations of long term survey sites, occurrence of appropriate habitat, evidence of use of the area by shorebirds, along with the potential to establish new survey sites within the MPA. However, the addition of survey sites within the MPA is contingent on the availability of skilled observers.

It was questioned whether time lapse photography is useful for conducting bird surveys. While time lapse photography has been used to address questions related to use of a location by birds, this technique is not presently being used in Atlantic Canada. In order to be most useful, the technique would have to be broadly deployed to determine whether factors within or outside the MPA are contributing to any observed differences.

Selection of appropriate indicator species is critical. Relevance of various bird species/groups to Musquash MPA monitoring was also discussed. Shorebirds and marshbirds were deemed most valuable in terms of contributing to the monitoring of ecosystem health within the MPA.

Presentation 2 Highlights

The **Maritimes Marsh Monitoring Program** (MMMP), a volunteer based pilot program, is a hybrid of several Marsh Monitoring Programs coordinated by Bird Studies Canada. Standardized survey protocols are implemented at point locations in several habitat types, e.g., wet meadow, shallow marsh, deep marsh, coastal wetlands (i.e., tidal salt marsh) and forested wetlands, with 17 survey locations located in the MPA. Six primary focal and 25 secondary focal species were identified in the MPA. Additional bioacoustic monitoring using song meters was completed at a subsample of sites. Time and type of detection (auditory vs. visual) data is collected for each individual of a primary focal species. Count data is collected for all other species and used to estimate indices of abundance. An analysis of data for primary species with an adequate sample size provides an estimate of abundance, occupancy and detection probability. Preliminary results indicate a mean species richness of 7.94 species per point within the MPA, with species richness values of 10.3 and 4.8 calculated for the upper basin and lower basin, respectively.

Discussion

It was noted that since the MMMP is in year two of a pilot program, no baseline data exist for the MPA; however, there is the potential to build a dataset.

Participants questioned how bird calls were recorded. It was clarified that for primary species each individual is tracked on a minute by minute basis over a 10-minute period, and any detections in the final 5-minutes are noted. For all other species, counts of the number of individuals detected in each of 3 5-minute intervals of the survey period are recorded.

There was also a question as to whether acoustics were completed automatically. It was noted that subsets of data in 5-minute intervals will be analyzed using a format that matches the field survey protocol (i.e., additional minute-by-minute detection histories of individual primary focal species birds will be generated from the recordings) to evaluate the detectability of various marsh-dependent species as a function of time of day and day of year.

Presentation 3 Highlights

The **Maritime Breeding Bird Atlas** (MBBA) provides information of the change in bird populations over time between the first (1986-1990) and the second (2006-2010) atlases. Atlas data consists of an inventory of intensive bird surveys conducted in 10 x 10 km squares over a 5-year interval every 20 years. Available data includes breeding evidence maps, relative abundance maps, georeferenced point count data and rare/colonial species data, and habitat association analysis for most species detected on point counts. All analyses conducted to date using MBBA data are at the provincial or Maritimes-wide scale.

Discussion

It was questioned whether it was possible to attribute changes to Musquash once a monitoring protocol is developed. The importance of an appropriate indicator species was noted since environmental conditions, such as ice cover, can impact bird distribution. While the MBBA is focused on monitoring regional (e.g., provincial) long-term changes in multiple bird species populations, the MMMP is designed specifically to evaluate local (e.g., watershed, MPA) and regional (e.g., provincial) scale changes in wetland bird populations.

Juvenile Fish
Presenter: E. Kennedy
Rapporteur: L. Bennett

Presentation Highlights

As Dave Methven was unable to attend, the Chair reviewed slides presented at a workshop held on January 29, 2013, at the St. Andrews Biological Station. The focus of the workshop was to review monitoring data collected from the Musquash Estuary MPA. A summary of the presentation and subsequent discussion are available at DFO 2013.

Discussion

Questions regarding sampling protocol and similarity of sampling sites were unable to be answered. The baseline values for species assemblages have not been identified, but participants agreed that the information is available to calculate such baselines. Discussion also suggested that the Musquash ecosystem is not unique from other areas in terms of fish assemblages; thus a control monitoring site should be located outside the MPA to control for influences on fish assemblages at a more regional scale.

Sediment Dynamics
Presenter: B. Law
Rapporteur: L. Bennett

Presentation Highlights

MERIS was an ocean colour sensor on board the ENVISAT satellite that was launched in 2002. It has been non-operational since 2012; however, a new and similar satellite system is expected to be launched in 2014. Total suspended matter (TSM) concentration and a colour dissolved organic matter (CDOM) concentration images, predicted from MERIS of the Musquash Estuary for October 14, 2010, were presented. Images indicate increased TSM and CDOM in the Musquash area in comparison to surrounding areas.

To date, most of the sediment sampling within the MPA has been opportunistic. Sediment and bottom core samples were analysed to determine sedimentation rate, trace metal concentrations, and grain size within the estuary. The techniques used in the sediment analyses, include the use of radio isotopes of lead and cesium to date sediments and ultimately determine sedimentation rate, lithium normalization to determine the anthropogenic influence of trace metals in to the system and a grain size normalizer, and a coulter multisizer for particle size analysis. The sedimentation rate for the estuary is approximately 0.5 cm per year which is a typical rate for bays and estuaries in the Maritime Provinces.

Although samples do not encompass the entire section of the MPA, analysis of sediment trace metal data from both surficial and core samples indicate all concentrations are at background values. There are no elevated levels of trace metals as a result of a leak at the Coleson Cove Power Plant which occurred in 2012.

Surficial grain size data from the MPA is considered incomplete. It was recommended that a surficial grain size survey be completed in the MPA to improve estimates of bottom stress for specific benthic habitats in the estuary. Coupled hydrodynamics sediment transport models would also be required for more comprehensive modeling of the physical drivers of the ecosystem.

Discussion

It was questioned whether sediments can be identified as coming from freshwater sources and, if so, whether freshwater inflow rates can be determined. While it is not possible to identify sediment from freshwater sources within bed sediment samples, it may be possible through the

examination of grain sizes of suspended sediment in a water sample. The slope of the disaggregated inorganic grain size distribution (m) can be used qualitatively to determine different source rocks if, for instance, the marine and freshwater sediment source is different. It was noted that this would be very difficult to determine. As for rates of sediment inflow from freshwater, if the river is gauged to determine flow velocity, an optical backscatter sensor (OBS) or transmissometer could be added and calibrated to determine the amount of sediment flux by multiplying the flow speed by the concentration as determined by the OBS or transmissometer.

There was a discussion as to whether the MPA and Saint John River Estuary have similar sediment concentrations based on satellite images. Initially, both appear to have similar sedimentation concentrations; however, this would require confirmation through the analysis of several satellite images. Saint John River has a higher freshwater input; it is therefore considered unlikely sediment concentrations will be similar for long periods of time. Sediment concentration has been resolved in the upper Bay of Fundy (Minas Basin, Chegnecto Bay) and also for the Northumberland Strait. Since satellite data is a snapshot at the time the image is captured, an analysis of long term records would be required to compare areas.

Clarification was provided on the statement that indicated additional sampling and data is required in terms of bottom sediment grain size. Additional sampling would provide the data required to map the distribution of mud and sand within the estuary. At present, most of the bottom sediment grain size data is from a homogenous sample of approximately 10–15 cm deep. This represents over a decade of sediment based on the sedimentation rates using radionuclides. It would be preferable to have a surficial map of grain size based on the top 0.5 cm, which is the material dominated by the mechanisms of advection, resuspension, aggregation, disaggregation, and deposition; the processes responsible for the formation and maintenance of the bottom sediment and subsequent habitat.

Human Ecosystem Pressures

Presenter: P. Doherty
Rapporteur: L. Bennett

Presentation Highlights

Available data for three ecosystem pressure indicators (commercial and recreational landings, by-catch number, size, age, and sex per impacted species, and degree of human induced habitat perturbation or loss) were reviewed.

An overview of fisheries allowed in the MPA was presented. Information pertaining to scallop fishery landings is available from the Maritime Fishery Information System (MARFIS) and fishermen's log books. Within the MPA, only the scallop fishery is currently required to report catch information at a scale that is useful for MPA monitoring. Data are available prior to MPA designation and could be used to compare usage pre and post designation. It is unclear whether current data provide an adequate basis for ongoing monitoring or whether the indicator will be effective in assessing ecosystem change. It was recommended that these data be analyzed annually to help explain changes in the ecosystem that are noted by other indicators. Reporting requirements for lobster, elvers, eels, herring, clams and dulse fisheries landings are not adequate for monitoring at the scale of the MPA. To date, no data has been collected to characterize the pressures presented by these fisheries.

It was recommended that the name of the indicator be changed from "By-catch number, size, age, and sex per impacted species" to "By-catch number per impacted species" due to the feasibility of acquiring data on size, age and sex of by-catch species. Data regarding by-catch number are collected by fisheries observers through the At-Sea Observer Program. Within the vicinity of the MPA, only the scallop fishery participates in the program and no trips to the MPA have included an observer. Given the gear used for the elver, eel, clam, and dulse fisheries, by-

catch is not likely an issue of concern. However, one approach to obtain data on by-catch is to carry out a Local Ecological Knowledge (LEK) study.

Data collected from surveys of marine debris, activity applications, aerial photographs (particularly those completed from 2001-2007), LiDAR surveys of intertidal areas, and satellite imagery may all be used to evaluate the degree of human induced perturbation or loss. Monitoring marine debris and/or activity applications as indicators are unlikely to be effective in assessing ecosystem change; however, it is recommended that the data be used to help explain changes in the ecosystem that are noted by other indicators. An initial survey of vulnerable shorelines could provide an adequate baseline for ongoing monitoring. LiDAR surveys can be used to determine shoreline delineation, identify vegetation types, and determine amount of vegetation cover. However, it may be difficult to distinguish human induced perturbation or habitat loss from those caused by natural processes using these data. Time-lapse video or photography was also suggested as possible options for monitoring shoreline activity.

Discussion

It was noted that aerial photographs of the MPA were captured by the New Brunswick Forestry Department in 2003 and by James W. Seawall Co. in 2007. LiDAR surveys of the lower and upper portions of the estuary were also completed by the Centre of Geographic Sciences (COGS) in 2006 and 2007. Once completed, an analysis of these data could provide a baseline of vegetation and habitat type within the estuary. While future monitoring could identify habitat changes in the estuary, an analysis of correlation with other parameters would be required to identify the cause of the change. The value of satellite imagery collected in 2010 was questioned since it was not collected in a manner suitable for MPA monitoring.

Participants discussed ways of improving the resolution of lobster and scallop landings data for the MPA. Improving data resolution is dependent on the fishery and grid that is fished. Changes to log book reporting are considered unlikely. Improving the resolution of lobster data would require the fishing grid to be adjusted as the size of the grid encompassing the MPA is quite large. It was cautioned that measures viewed as a burden to fisherman should only be considered once an impact or issue is identified. Rather, changes that do not result in additional administrative or financial effort should be considered. A collaborative approach between DFO and fisherman should be pursued if additional information regarding fishing activities within the MPA is required.

Habitat Classification

Presenter: M. Greenlaw
Rapporteur: L. Bennett

Presentation Highlights

Areas that are expected to have similar community composition to Musquash Estuary were suggested based on a subtidal ecological classification scheme. The presented classification scheme is based on meso-scale physiographic features and smaller micro-scale habitat distribution patterns. Within the Passamaquoddy physiographic region there is expected to be similar community composition patterns in subtidal muddy habitats, intertidal sand flats and marshes within inlets, especially within areas with similar salinity, temperature and turbidity regimes. Mud flats/marshes in the same oceanographic domain will likely have similar community distribution and there is expected to be a degree of overlap between muddy habitats in other close oceanographic domains. Also expected is a degree of overlap between subtidal muddy habitats in Musquash and subtidal muddy habitats in the 0-50 m bathome (outside inlets) in the Quoddy 3 physiographic region. Moreover, there is an expectation of a certain lesser, but possibly still significant degree of overlap between subtidal muddy habitats, intertidal sand flats, and marsh areas in other close physiographic units (inner Bay of Fundy, Grand Manan Bank and Grand Manan Basin, and possibly Western Nova Scotia).

Musquash does not seem to have any unique habitat types, that are not present elsewhere in the Quoddy Region, as subtidal muddy habitats, intertidal sand flats, and marshy habitats are present within more than one inlet. Musquash is only unique in proportion of these habitat types, and may have a higher proportion of marshes and intertidal sand flats than other inlets within the Quoddy Region. This also suggests that Musquash would not likely house any unique or rare species.

Discussion

Participants noted that sites used for comparison outside of the MPA should be located within a similar habitat within a similar oceanographic domain.

Review of Recommended Changes to the Indicators, Strategies, and Protocols

Discussion

A list of proposed changes to the 2010 Musquash Estuary MPA Ecosystem Monitoring Framework is provided in the accompanying SAR. Recommended changes were grouped based on the three themes for conservation objectives: productivity, biodiversity, and habitat.

1. Productivity

The indicator "Total biomass and spatial distribution of species in each trophic level within each ecotype" was considered very broad and participants were unclear how progress could be made with this indicator. It was recommended that key species across trophic levels as opposed to ecotype be identified. Including key bird species was recommended since they are generally higher in the trophic level and may indicate changes in lower trophic levels (i.e., productivity changes in higher trophic levels may be resultant from changes in lower trophic levels). In addition, a proxy for biomass, as an indicator for productivity should be identified as it can be difficult to determine biomass because of the required sampling effort.

Participants considered the significant amount of sampling required to capture trends and establish a baseline for phytoplankton within the MPA unfeasible. Ttherefore, it was recommended that the indicator "Phytoplankton concentration within the estuary" be removed.

It was suggested that the name of the indicator "Commercial and recreational fishery landings" be changed to "Commercial and recreational fishery catch per unit effort (CPUE)" as CPUE was considered a more appropriate measure of productivity.

It was recommended that the magnitude of change from a baseline value that would result in management action should be determined for indicators. This change threshold could be considered a reference point. Reference point is defined as a point that once it is exceeded triggers further management action. A strategy to determine reference points for indicators was discussed and requires further consideration. Sampling to determine natural variation around each indicator would serve as the baseline. Comparison of future sampling data to the baseline values would indicate if an indicator, e.g., species abundance, is significantly different. Statistical deviation (amount of deviation to be determined) from this baseline distribution would trigger further action. As well, once this deviation from the baseline is identified, discussion is needed to determine the acceptable level of sampling frequency required to defensibly calculate such deviation.

The issue with identifying such reference points for specific indicators is that it is unlikely that management action will occur based on one indicator value falling outside the threshold limit; rather it is more likely that management action would result from numerous indicators showing change outside natural variation. Thus, management action likely would be tied to a suite of indicator values rather than single values.

Two monitoring strategies for all indicators were discussed. The first is an intensive sampling period, with sampling period dependent on indicator, every 5-10 years with the goal to understand ecosystem function, determine the natural variability inherent in the system, and compare results to previous sampling periods. The second is to conduct smaller subsets of sampling more frequently to maintain an understanding of how key components of the ecosystem are reacting to threats and pressures.

2. Biodiversity

Participants considered the sampling required to estimate the "number of species in each ecotype in each trophic level within each ecotype, and the abundance of keystone and/or dominant species" unachievable. It was noted that information on specific groups within trophic levels, e.g., juvenile fish, birds, is available. It was recommended that key plant species should be included in the monitoring plan. Acadian Seaplants may have data on biomass for seaweeds in the area, thus discussions regarding sampling protocol and data accessibility with industry should be initiated.

It was noted that benthic invertebrate sampling should be conducted in the upper estuary to obtain a better understanding of their function as prey for many species including birds, and to determine the linkage between the different trophic groups. However, access to the upper estuary for sampling purposes is challenging since motorized boats are not permitted above Five Fathom Hole.

As part of the Atlantic-wide monitoring program for Aquatic Invasive Species (AIS), a monitoring station was set up in the Musquash MPA over the past six years. There have been no AIS detected in the MPA as part of this monitoring program.

Because information pertaining to size, age and sex of impact species are not collected by at sea observers and the resources required to collect the information is considered unfeasible it was recommended that the indicator "By-catch number, size, age, and sex per impacted species" be renamed "By-catch number per impacted species".

3. Habitat

While no changes were recommended to habitat related indicators, it was suggested that contaminant sampling and analysis be completed when a potential threat is identified due to the cost associated with contaminant analysis. In addition, higher frequency sampling was suggested until baselines are established after which less frequent sampling could be completed.

It was recognised that some indicators, such as data on biogenic structures, have not received any attention while external organisations, such as Eastern Charlottetown Waterways (ECW) may carry out monitoring activities that can establish baseline values for other indicators, such as nutrient concentrations. ECW is funded under Environment Canada to conduct water sampling in the MPA. This initiative may be ongoing every two years. This indicator will likely require more intensive sampling initially to capture seasonal cycle and variation.

Review of Data Management Practices

Discussion

There was a discussion concerning the challenges of data management in general and more specifically with MPA data within DFO. Data often remains with the individual who collected it. The need of a data repository was recognized. Participants identified the need for a master database which houses all data, generates required data products, and maintains a log record of changes. The capacity to maintain such a management effort will be a challenge. It was suggested that existing databases be utilized rather than creating a new product. Data within these databases would need to be identified as originating from MPA monitoring, which can be

a challenge since these databases have not been designed for this function. The importance of documenting decisions based on data products was also noted as was the importance for the data to be accessible for other researchers and managers involved in the MPA activities.

ECOLOGICAL DATA ASSESSMENT (SEPTEMBER 19, 2013)

The data assessment meeting held from June 25-27, 2013, was reconvened via teleconference on September 19, 2013, at the Bedford Institute of Oceanography, Dartmouth, NS, to finalize the SAR. After minor modifications, the SAR was finalized and accepted by participants.

REFERENCES CITED

DFO. 2013. Review of the Musquash Estuary Marine Protected Area (MPA) Monitoring Data. DFO. Can. Sci. Advis. Sec. Proceed. Ser. 2013/018.

APPENDIX 1

Review of the Musquash Estuary Marine Protected Area (MPA) Monitoring Data Results

June 25-27, 2013

Hunstman Marine Science Centre
St. Andrews, New Brunswick

ATTENDEES

Name	Affiliation
Abbott, Matthew	Conservation Council of NB (CCNB)
Allard, Karel	Environment Canada / Canadian Wildlife Service
Bennett, Lottie	DFO Maritimes / Centre for Science Advice
Blanchard, Marc	DFO Maritimes / Coastal Ecosystem Science
Campbell, Margaret	Bird Studies Canada
Chang, Blythe	DFO Maritimes / Coastal Ecosystem Science
Cheney, Sarah	DFO Maritimes / Resource Management, SWNB
Cooper, Andrew	DFO Maritimes / Coastal Ecosystem Science
Corkum, Jessica	Dalhousie University
Doherty, Penny	DFO Maritimes / Oceans and Coastal Management
Greenlaw, Michelle	DFO Maritimes / Coastal Ecosystem Science
Kennedy, Eddy	DFO Maritimes / Coastal Ecosystem Science
Law, Brent	DFO Maritimes / Coastal Ecosystem Science
Martin, Jennifer	DFO Maritimes / Coastal Ecosystem Science
Page, Fred	DFO Maritimes / Coastal Ecosystem Science
Pohle, Gerhard	Huntsman Marine Science Centre
Singh, Rabindra	DFO Maritimes / Population Ecology
Westhead, Maxine	DFO Maritimes / Oceans & Coastal Management

Review of the Musquash Estuary Marine Protected Area (MPA)
Monitoring Data Results

September 19, 2013

Bedford Institute of Oceanography
Dartmouth, Nova Scotia

ATTENDEES

Name	Affiliation
Allard, Karel	Environment Canada / Canadian Wildlife Service
Bennett, Lottie	DFO Maritimes / Centre for Science Advice
Chang, Blythe	DFO Maritimes / Coastal Ecosystem Science
Cooper, Andrew	DFO Maritimes / Coastal Ecosystem Science
Doherty, Penny	DFO Maritimes / Oceans and Coastal Management
Kennedy, Eddy	DFO Maritimes / Coastal Ecosystem Science
Law, Brent	DFO Maritimes / Coastal Ecosystem Science
Westhead, Maxine	DFO Maritimes / Oceans & Coastal Management

APPENDIX 2

Review of the Musquash Estuary Marine Protected Area (MPA) Monitoring Data

Regional Peer Review – Maritimes Region

Part 1 – Data Review: January 2013 (St. Andrews, NB)
Part 2 – Assessment: June 2013 (St. Andrews, NB)

Chair: Eddy Kennedy

TERMS OF REFERENCE

Context

The Musquash Estuary in southwest New Brunswick is unique in the region due to its size, expansive salt marshes, and relatively undisturbed natural condition. It is the largest ecologically-intact estuary in the Bay of Fundy. It exhibits a diverse number of habitat types and related biological communities. On December 14, 2006, the lands and waters in the Musquash Estuary, up to the ordinary water level at low tide, were designated a Marine Protected Area (MPA) through regulations made pursuant to Canada's *Oceans Act*. Certain intertidal areas adjacent to the MPA are also administered and protected by Fisheries and Oceans Canada (DFO) (i.e., Administered Intertidal Area or AIA). Although the MPA is regulated via the *Oceans Act* and the AIA is regulated via the *Fisheries Act*, the intent is to monitor and manage both areas holistically as an MPA. For the remainder of the document, any reference to the Musquash Estuary MPA will imply both the MPA and AIA.

In support of the Health of the Oceans Initiative (HOTO), DFO Science Branch is required to deliver scientifically defensible indicators, protocols, and strategies for monitoring MPAs that have been designated pursuant to the *Oceans Act*. To meet this requirements, DFO Science Branch developed an Ecosystem Monitoring Framework to address the conservation objectives for the Musquash Estuary MPA, consisting of a suite of fifteen indicators and advice on how to implement a cost-effective monitoring program that incorporates existing monitoring programs, protocols and strategies to the extent possible (DFO 2011). A Maritimes Region Science Advisory Process was conducted in December 2010 to review this framework. It was acknowledged that there was a lack of baseline data for many aspects of the Musquash Estuary ecosystem, thus, the proposed indicators were general rather than specific, with a range of monitoring strategies and protocols proposed as a first step to evaluating the indicators in tandem with improving baseline knowledge.

The proposed Regional Peer Review meetings would provide an opportunity to present and discuss relevant data that has been collected to establish a baseline for some of the indicators proposed within the Musquash Estuary MPA Ecosystem Monitoring Framework. These meetings will also provide an opportunity to discuss the proposed monitoring indicators, protocols and strategies (including data management considerations) to determine if changes are required to meet on-going MPA monitoring needs. The invitee list for the first meeting will focus on individuals or organizations that have been collecting monitoring data while the invitee list for the second meetings will focus on a broader audience.

Objectives

Part 1 – Data Review

- To review preliminary results of the analyses of relevant data that have been collected to establish a baseline for the ecological indicators identified in the Musquash Estuary MPA Ecosystem Monitoring Framework. Specific questions to be addressed are:
  - What data have been collected, and how do they contribute to establishing adequate baselines for the Musquash MPA?
  - What were the collection methodologies used (strategies and protocols)?
  - Based on lessons learned, what changes should be made to these collection methods in the future?
  - How should the data be analyzed (including any preliminary results)?
  - How could different data sets best be integrated and reported as indicators of ecosystem change?
- To discuss possible strategies to address indicators (data gaps) that have not been, but still should be, included for effective monitoring of the Musquash Estuary MPA.
- To review proposed data management practices [and work flows] for historical and on-going data collection and analyses related to the Musquash Estuary MPA.

Part 2 – Assessment

- To review final results of the analyses of relevant data that have been collected to establish a baseline for the ecological indicators identified in the Musquash Estuary MPA Ecosystem Monitoring Framework. Specific questions to be addressed are:
  - Does the data collected to date provide an adequate baseline for on-going monitoring of the Musquash Estuary MPA?
  - Are the indicators monitored/presented to date likely to be effective in assessing ecosystem change?
- To provide recommendations on any changes to be made to the indicators, strategies, and protocols proposed in the 2010 Musquash Estuary MPA Ecosystem Monitoring Framework.
- To report on progress made on the data management practices [and work flow] for historical and on-going data collection and analyses related to the Musquash Estuary MPA.

Expected Publications

- Proceedings
- Research Documents
- SAR (Assessment meeting only)

Participation

- DFO Science Branch
- DFO Ecosystem Management Branch
- DFO Fisheries and Aquaculture Management Branch
- Environment Canada
- Academia
- Non-Government Organizations
- Fishing Industry
- Province of New Brunswick
- Aboriginal communities / organizations

Reference

DFO. 2011. Musquash Estuary: A Proposed Monitoring Framework for the Marine Protected Area and Intertidal Area Administered by Fisheries and Oceans Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/040.

APPENDIX 3

Review of Existing Data, Protocols, and Procedures for the Musquash Estuary MPA Ecosystem Monitoring Plan: Part 2

Regional Peer Review – Maritimes Region

June 25-27, 2013

Huntsman Marine Sciences Centre
St. Andrews, New Brunswick

Chair: Eddy Kennedy

DRAFT AGENDA

June 25, 2013 – Tuesday

13:00- 13:15 Introduction

13:15- 13:45 Summary of Musquash Estuary MPA Monitoring Framework and Science Advisory Report

13:45-14:30 ToR 1- Review of final results of collected data

- Benthic Biodiversity
- Oceanography

14:30–14:45 Break

14:45-16:00 ToR 1 - Review of preliminary results of data collected

- Plankton
- Bird surveys

June 26, 2013 - Wednesday

09:00-09:15 Day 1 Recap

09:15-10:30 ToR 1 - Review of preliminary results of data collected

- Juvenile Fish
- Sediment Dynamics
- Ecosystem Pressures
- Other monitoring data
- General discussion and summary of main findings for TOR 1.

10:30-10:45 Break

10:45-12:00 Discussion and summary of main findings for TOR 1.

- Does the data collected provide an adequate baseline for on-going monitoring?
- Are the indicators monitored likely to be effective in assessing ecosystem change?

12:00-13:00 Lunch (not provided)

13:00-14:30 ToR - 2 Recommendations on changes to indicators, strategies and protocols in the Monitoring Framework

- General discussion in the context of whether the current suite of indicators provides complete and effective ecological monitoring that can assess whether the conservation objectives for the Musquash MPA are being met.

14:30-14:45 Break

14:45-15:45 ToR 3 - Review of proposed data management practices

- Data management issues and recommendations

15:45-16:30 Summary and Next Steps

June 27, 2013 - Thursday

09:00-09:15 Day 2 Recap

09:15-10:30 SAR Review

10:30-10:45 Break

10:45-12:00 Review SAR

Due to time constraints, the review of the SAR was not completed. To complete this task, the meeting was reconvened via teleconference for the afternoon of September 19, 2013.